Heat: An Agent of Change

Insulators and Conductors: The Coefficient of Conductivity

STUDENT TEXT

Have you ever thought about why sand is cool and blacktop hot when you walk across either on a hot summer day? Or on a *really* hot summer day, a barefoot person usually walks across a cement driveway much faster than a grassy lawn. Why does the handle of a wooden spoon feels cooler to the touch than the handle of a metal spoon, even if both spoons are sticking out of the same pot of hot soup? Why does a plastic tray of ice cubes removed from the freezer feel warmer than a metal tray of ice cubes?

For each pair of materials in these examples, the substances are in the same environment and their temperatures are equal, yet they do not feel the same to our touch.

A scientist would say, "Even though the temperatures are equal, the *coefficient of conductivity* varies from substance to substance." She would mean that heat flows through some substances more quickly and easily than through others.

In the "Three Methods of Heat Transfer" activity you heated a metal rod and watched drops of wax fall off. Now imagine you and your classmates are the molecules in that metal rod. You are lined up very close together so that the kinetic energy you exhibit through vibrating, spinning, and moving is being transmitted to other molecules near you.

You can simulate this by lining up very close together with 8–10 other students. Put one hand on the shoulder of the person to your left, and the other on the shoulder of the person to your right. The first person in the line should begin to move like a molecule, vibrating, spinning, and moving. This molecule's kinetic energy affects the other molecules near it. Those molecules start to move and to affect their neighbors. This shows how quickly the energy is transmitted in the metal rod.

If your group were simulating a wooden dowel, things would be much different. To try it, move farther apart in the line until you are a full step away from each neighbor. Every other person drops his or her hand from one neighbor's shoulder. Now when the first person in line moves like a molecule, there are gaps in transmission, and the movement is much slower.

This is the difference between a good conductor of heat and a poor one. Substances that conduct heat well are called **conductors**. They have high **coefficients of conductivity**. This is a constant number by which we can compare substances according to how well they conduct heat.

Substances that do not conduct heat well are called **insulators**. The word insulator comes from the Latin word *insula*, which means *island*. That makes sense when we consider that insulation is supposed to keep a substance at a particular temperature, even though the surrounding temperature is different**.** Insulators have a low coefficient of conductivity; they do not conduct heat well. Nonmetals, such as wood, textiles, and plastic, are usually poor conductors. Gases are also poor conductors.

The term **coefficient** means a number value that can be calculated for each substance so different materials can be more easily compared. Copper is a very good conductor of heat. Scientists rate it at 386 W/m-^{o}K. Water and wood are insulators, and are not good conductors of heat. Water has a coefficient of conductivity of .6 W/m-^{o}K and wood averages 0.1 W/m-^{o}K. (If air is not a good conductor of heat, would its coefficient be a large number or a small number?)

You can compare coefficients of conductivity for different materials to tell which are insulators and which are conductors. In the following table, notice that copper has a value over one, while water and wood have very small decimal values. Study the table to determine which are conductors and which are insulators.

Material	**Coefficient of Conductivity W/m-^{o}K**	**Conductor or Insulator?**
Copper	386	
Water	.6	
Wood	.1	
Aluminum	204	
Glass	.78	
Lead	35	
Engine oil	.14	
Cork	.043	
Brick	.69	
Felt	.036	
Iron	73	
Tin	64	
Skin	.3	
Steel (depends on composition)	40-70	
Tungsten	163	
Air	.03	
Hydrogen	.18	
Helium	.17	
Oxygen	.03	
Nitrogen	.026	
Mercury	9	
Wallboard	.048	